Timing is crucial when it comes to understanding the origins of humanity. Developing better dating techniques to discover the ages of key fossils will help scientists to discover how Homo sapiens and our relatives evolved.

Going back to basics could help to unlock the mysteries of human evolution.

Our origins have been notoriously difficult to decipher, with a variety of contradictory and controversial evidence making it hard to work out exactly how our species evolved.

A new paper, published in the journal *Quaternary Science Reviews*, proposes a simple, two-pronged solution—find more fossils, and better date the ones we already have. Doing so will help to fill in large pieces of the evolutionary puzzle and help resolve longstanding dilemmas in the field.

Professor Chris Stringer, an expert in human evolution at the Natural History Museum who co-authored the paper, says, "Despite more than a century of study, there are many regions of the world that are still underexplored for fossils.

"While stone tools suggests there must be sites to be found, large parts of Arabia, the Indian subcontinent, southeast Asia and central and west Africa haven't been well explored. Where we have, unusual species like Homo floresiensis and Homo luzonensis show what could be there if we take the time to look.

How are fossils dated?

Ever since the first fossils of human relatives were discovered in the nineteenth century when the bones of Neanderthals were dug up in Gibraltar and Germany, scientists have been trying to piece together our origins.

But as scientists traced our evolutionary journey back through time there have been a few roadblocks. The status of some ancient human species have been questioned, while large gaps in the fossil record mean that the exact path of evolution is difficult to work out.

This is where dating comes in. By working out the age of the fossil (or the sediment it was buried in) researchers can start to better untangle the series of events in the evolution of humans and our relatives.

Many techniques, such as radiocarbon dating, rely on the decay of radioactive elements. After an organism dies, the levels of a naturally occurring radioactive form of carbon, known as carbon-14, will fall as it gradually transforms into a more stable form of the element.

As this occurs at a steady rate, the exact proportion of carbon-14 left in the remains of animals can be used to work out how old a fossil is.

Other methods, meanwhile, depend on the physical structure of the fossil. Amino acid dating, for instance, relies on a curious quirk of living things: all of their amino acids, the building blocks of proteins, point in the same direction.

After death, some of the amino acids begin to flip, so the amount pointing in each direction can be used to work out the age of a sample.

Even with these different techniques, dating can be a tricky business. For example, radiocarbon dating only works for fossils that are 50,000 years old or younger, while amino acid dating fell out of favor when it was stretched beyond its capabilities.

It's also a question of geology. Even if a bone is of a certain age, it might be buried in substrate which is much younger or older. This affected the discovery of Homo floresiensis, which was initially thought to be less than 20,000 years old based on the dating of charcoal fragments.

In reality, it turned out a much younger layer of sediment had intruded into an older region, with the bones being closer to 60,000 years old.

To avoid issues like these, where possible researchers now try to directly date bones. As part of a comprehensive review of the subject, Chris and his colleague Professor Rainer Grün have tried to provide more precise timings for human fossils all over the world.

Rainer says, "This paper re-examines many existing sites that are important to the study of human evolution, providing some astonishing findings while reflecting our complementary research collaboration and friendship over the last 37 years."

Turning back the clock

To date these sites, Chris and Rainer made use of another technique known as uranium series dating. Similarly to radiocarbon dating, this instead looks at the proportion of uranium isotopes in fossils as they break down.

While this technique can date fossils that are hundreds of thousands of years old, giving it an advantage over other methods, it's not completely straightforward.

"The problem with bone is that it's an open system," Chris says. "Uranium can get into the bone, allowing it to be dated, but this also means more can be added or washed out over time.

"Previously, to get around this problem, scientists could cut the fossil in half and track the uranium all the way through the bone. But this isn't feasible on valuable human fossils. Instead, Rainer has helped to miniaturize the process, so that tiny samples can be taken using lasers to minimize damage to important areas of the specimen."

This dating technique has been particularly useful at the Apidima cave site, where a fossil of early Homo sapiens dating back more than 210,000 years has been found. This makes it currently the earliest evidence of our species in Europe and Asia, but the finding has been controversial.

"The Homo sapiens skull fragment was around 40,000 years older than a Neanderthal cranium at the site, which is an odd situation as we'd generally expect it to be the other way around," Chris says.

"Some scientists argued that they must have been the same age, but our new analyses show they have different depositional histories. They couldn't have been buried at the same time."

Some of their other findings throw up new questions. For example, some specimens of the species Homo luzonensis might be as much as 135,000 years old, which is more than double the age it is currently thought to be.

Chris and Rainer hope that as dating techniques are continually improved, other researchers will go back and calculate even more precise ages for the fossils, and apply the methods to many more specimens.

"It's hard to predict what new techniques will emerge, but I think we could see the refinement of existing methods," Chris says. "There's been a renewed interest in using amino acid dating, which is providing promising results based on tooth enamel and mollusc fragments from sites in Britain and beyond.

"DNA dating, which uses the mutation rate to assess how old a fossil is, is also growing in importance.

"Providing these techniques are used carefully, then I think the outlook is excellent for increasing our understanding of human evolution."

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One argument against fossil evidence is the idea that fossil dating could be inaccurate. Fossil dating is done using Carbon 14, but for it to be of value, the amount of C-14 must have always been a constant. If the intensity of radiation (specifically cosmic radiation) differed in any way, then the C-14 dating system would be flawed. Scientists discovered fossils throughout the various layers of the earth according to the time period the organisms corresponded with. The bottom layers contained species associated with the beginning of the earth, while the top layers contain more recent and advanced species, especially mammals. Evolutionists feel that these findings strongly argue for evolution. They feel that if God had created the earth and everything on it, all fossil remains would be mixed together. Creationists argue that the reason for the fossils being distributed the way they are is because of the Great Flood. Most of the time creationists avoid this topic because of the lack of evidence they have against it. The controversy continues whether gradual evolution took place, and if it did occur, why was it not evident in fossil records. “The ferocity of the battle suggests that sudden leaps in the record would imply God’s direct role in evolution while gradualism would mean randomness and no role for God”

Evolution theory in biology postulating that the various types of plants, animals, and other living things on Earth have their origin in other preexisting types and that the distinguishable differences are due to modifications in successive generations.